Habitat Studies

Status and Trends of Galveston Bay Wetland Habitats

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The Scientific/Technical Advisory Committee of the Galveston Bay National Estuary Program (GBNEP) recognized the status of wetland habitats as a high-priority problem in characterizing the living resources of the Galveston Bay system, because the distribution and extent of wetland and aquatic habitats commonly reflect many other components of the ecosystem. Wetland and aquatic habitats are the principal nursery grounds for most occupants of the ecosystem, and they are the home of many mature biota as well. Knowledge of the present distribution of wetland and aquatic habitats and historical alterations of their locations is critical to managers who plan stabilization of these habitats for the future.

For this Galveston Bay system study, the objectives were:

1. To provide a bibliography of wetland and aquatic habitat references and an inventory of available aerial photographs of the shorelines;

2. To produce 1956, 1979, and 1989 habitat maps in digital line graph format from aerial photographic interpretation;

3. To determine the detailed wetland assemblages with surface traverses in the field and to conduct ground-truth studies of map photointerpretation;

4. To analyze trends of habitat gains and losses among 1956, 1979, and 1989 mapped habitat distributions; and

5. To explain causes of wetlands changes to provide models for wetlands management.

This project is designed to determine historical trends and current status of Galveston Bay habitats, including wetlands surrounding the bay itself, fringing fresh, brackish, and salt marshes, intertidal habitats, and submerged aquatic habitats including sea grasses. The project will provide geographic information system (GIS) data sets consisting of electronic information overlays corresponding to mapped habitat features. This system is expected to become a flexible and valuable management tool for future use by resource agencies.

The study will be based on analyses of high-altitude aerial photographs available for 1956, 1979, 1987, and 1989. In particular, analyses of most recent aerial photographs will be compared with habitat analyses previously conducted by the

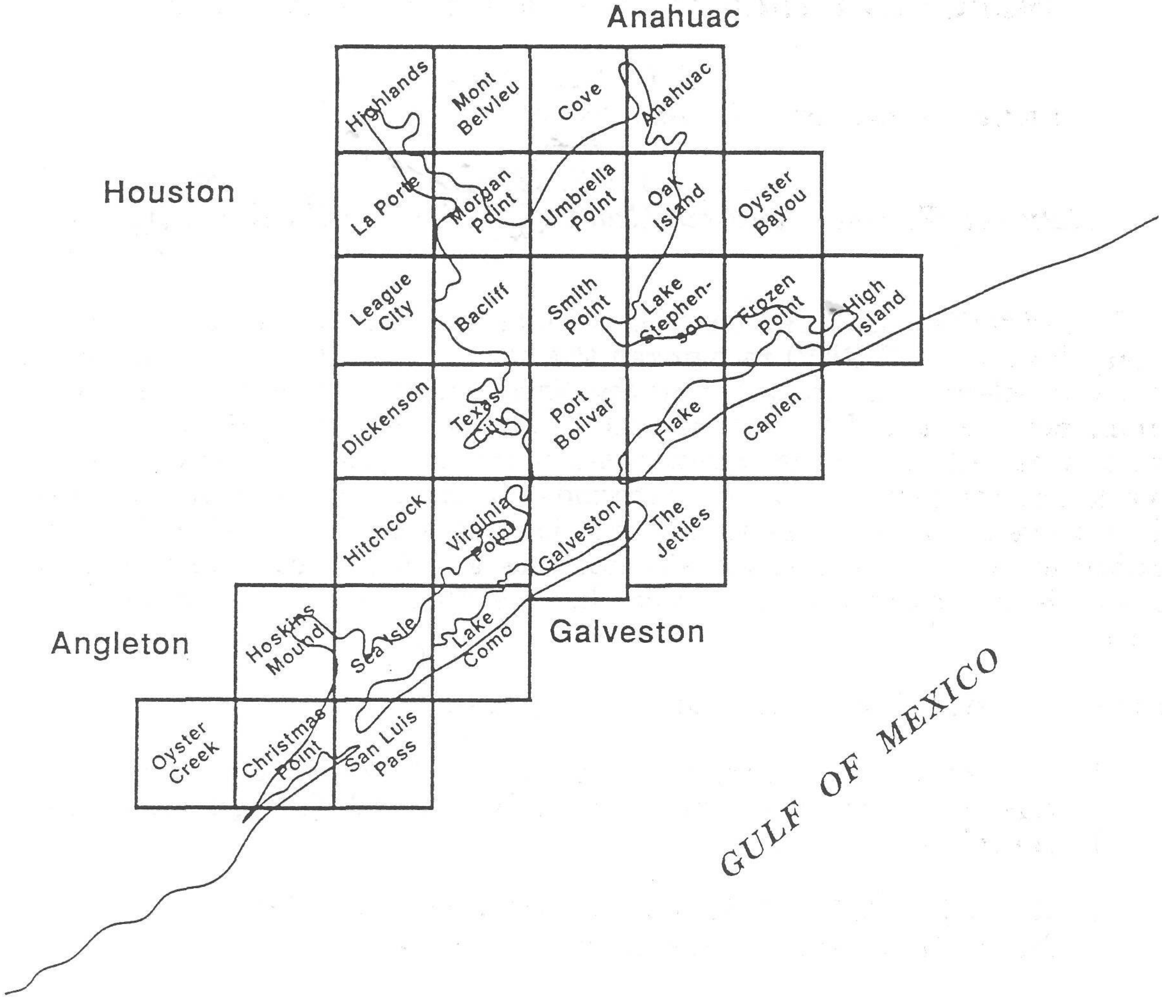

Figure 1. The 30 1:24,000-scale topographic quadrangles that cover the Galveston Bay system and on which wetlands identified on 1989 aerial photographs will be mapped.

U.S. Fish and Wildlife Service (USFWS) based on the photos from 1956 and 1979. The study area will correspond to the 30 quadrangle maps utilized by the USFWS in these previous studies (Fig. 1).

Areal extent of the various habitat types, classified after Cowardin *et al.* (1979), will be defined and verified by conducting ground-truth studies of plant species associations and by conducting interviews with persons familiar with the habitats. These studies will help determine the degree to which species associations can be differentiated by use of aerial photographs.

Results will be compiled in digital form and summarized in both map and written form. Maps will be digitized for incorporation into a GIS, whereby the recognized habitat types and other geographic features can be manipulated as information overlays, and whereby scaling and selection features will allow portions of the estuary to be electronically selected for specific analysis.

Results to Date

All literature on wetland and aquatic habitats of the Galveston Bay system were located, placed into a computerized database on microcomputers, and printed as a bibliography. A helpful source of literature was the Galveston Bay Bibliography at the Galveston Bay Information Center; all pertinent citations in the files of the Galveston Bay Bibliography were added to the system at the Bureau of Economic Geology.

All available photographs for the Galveston Bay system were inventoried. The inventoried area included 30 U.S. Geological Survey (USGS) 1:24,000-scale quadrangle maps, or four 1:100,000-scale quadrangles. The primary source for information on aerial photographs was the Texas Natural Resources Information System (TNRIS). Additional sources of photographs not in the TNRIS inventory were the General Land Office, Texas Department of Highways and Public Transportation, and private aerial photography companies.

Field transects were surveyed to establish a method for identifying representative wetland species communities and to relate community variations to elevation, soils, and salinity. Additional parameters that control species assemblages were examined. Representative plant communities were surveyed to help define the limits to which photointerpreters could identify and delineate specific communities.

The National Wetlands Research Center (NWRC) developed a Task Order with the National Wetlands Inventory (NWI) for the photointerpretation and mapping of the wetland and upland habitats for 30 USGS quadrangles (1:24,000) surrounding Galveston Bay. Photo preparation included: (1) indexing the photographs at NWRC on 1:250,000-scale maps; (2) determining photographic coverage of the 30 1:24,000-scale quadrangles to be completed; (3) preparing photos with overlays and delineating areas of quadrangle coverage; and (4) previewing the photos for a pre-photointerpretation field trip.

Upon completion of the photo preparation, a five-day field trip was made around the Galveston Bay area to establish signatures for wetland and upland habitat types. Researchers correlated plant communities with aerial photographic signatures and related the quantitatively-defined plant communities to various water and salinity regimes.

The photointerpretation of wetland and upland habitats from 1989 color-infrared aerial photographs is underway for the ten quadrangles agreed upon as initial areas for review. Photointerpretation of the San Luis Pass and Christmas Point quadrangles has been completed. USFWS expects photointerpretation of all ten quadrangles to be completed for review by early February, 1991.

The NWI 1956 and 1979 digital habitat data were converted for 30 quadrangles. The data were originally digitized and analyzed by the USFWS using the Wetlands Analytical Mapping System (WAMS) and the Map Overlay and Statistical System (MOSS) on a mainframe computer. For delivery to the GBNEP, the data were converted from a 1980 version to a 1990 version of MOSS on the computer now used at the NWRC. The data were then converted from a MOSS format to a digital line graph format, which has been converted to a format usable by Texas State agencies.

Utility

The analysis of wetland and aquatic habitats will be a major component of the GBNEP's Comprehensive Conservation Management Plan (CCMP), which must be completed for the U.S. Environmental Protection Agency (EPA) in 1994. Fortunately, the USFWS and the Bureau of Economic Geology previously mapped the distribution of wetland and aquatic habitats on 1956 and 1979 aerial photographs (Fisher *et al.*, 1972; U.S. Fish and Wildlife Service, 1982; White *et al.*, 1985; and Pulich and White, 1990). Mapping techniques are therefore established, 1989 aerial color-infrared photographs are available, and digital graphic trend analysis is a well-established technology. These aspects of the work will permit the preparation of 1989 status maps for the wetlands and trend analyses of distributive changes for the periods: 1956 to 1979, 1956 to 1989, and 1979 to 1989.

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Galveston Bay Habitats: Structure and Function in Relation to Fisheries Production

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Galveston Bay research of the NMFS Galveston Laboratory addresses relationships between estuarine environments and fisheries production. Current projects involve: 1) evaluation of habitat utilization by fishery species; 2) determination of factors affecting abundances of juveniles; 3) creation of salt marshes that benefit fisheries; and 4) development of estuarine information and data inventories.

Comparative Utilization Among Habitats

This project was designed to characterize faunal utilization of shallow water habitats in Galveston Bay (from the Trinity River delta to Christmas Bay (Figure 1). To accomplish this work, Zimmerman, Minello and Zamora (1984) developed a 2.6 m^2 drop trap sampling method that measures densities of shrimps, crabs and fishes for equitable comparison among a variety habitats. Marshes, submerged aquatic vegetation (SAV), oyster reefs, and bare mud and sand bottoms have been compared for utilization by fishery juveniles using this method (Zimmerman and Minello, 1984; Zimmerman, Minello, Baumer and Castiglione, 1990). Densities of known prey species (benthic epifauna and infauna) were measured from sediment cores taken in each drop trap sample, to determine predator-prey abundance relationships. Water quality and vegetational parameters were measured to complete habitat characterization. The work incorporates manipulative laboratory and field experiments on the effects of predators, food, salinity and hydroperiod on habitat utilization. These studies represent the first steps toward understanding functions of estuarine habitats in Galveston Bay for fishery species. Coupled with trend assessments of habitat degradation, these data are being used to establish procedures for conservation of essential habitats for fishery species in Galveston Bay. Results to date indicate high degree of utilization in lower and mid-bay habitats (Zimmerman, Minello, Castiglione and Smith, 1990) and emphasize the importance of marsh and seagrass areas as nurseries (Minello and Zimmerman, 1983; Minello, Zimmerman and Barrick, 1990; Thomas, Zimmerman and Minello, 1990).

Factors Affecting Abundances of Fisheries Species

Another key research problem is the affect of the physical environment on relationships among abundance, growth and survival of estuarine-dependent fisheries species. Important species in Galveston Bay include brown shrimp (*Penaeus aztecus*), white shrimp (*Penaeus setiferus*), pink shrimp (*Penaeus duorarum*), blue crab (*Callinectes sapidus*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*) and spotted seatrout (*Cynoscion*

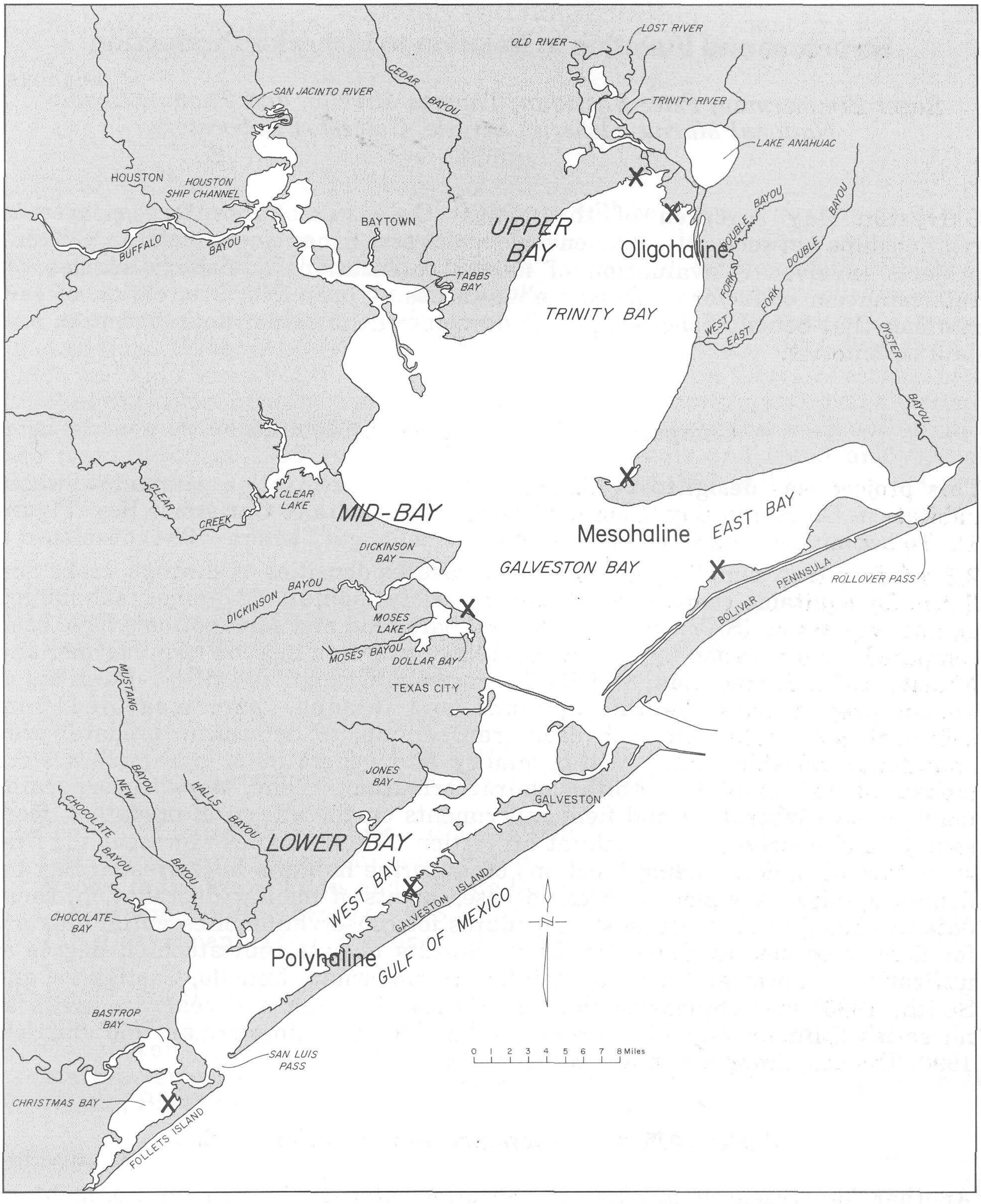

Figure 1. Salinity regimes and NMFS marsh study sites in Galveston Bay.

nebulosus). In the past, this work has collectively employed otter trawls (Sheridan, 1983), the hand-pulled Renfro beam trawl, and drop trap sampling to estimate abundances of fishes and shrimps. Work using drop trap sampling at a marsh on Galveston Island has concentrated on baseline measurements since 1982. At this site, animal abundances are monitored monthly as field instruments continuously record temperature, salinity, dissolved oxygen and tide level. In other work, the spring influx of postlarval brown shrimp through Galveston Pass is monitored using a Renfro beam trawl, continuing from the work of Baxter and Renfro (1967). Findings to date reveal many details of how fishery production depends upon factors which vary annually and may change over the long term, including: strength of annual recruitment of immigrating postlarvae, predation pressure, prey abundances, density of competitors (inter- and intraspecific), habitat change, meteorological effects and variability of tides. These data and information from the bait fishery in Galveston Bay (Baxter, Furr and Scott, 1988) make possible yearly forecasts of yields for the Texas brown shrimp fishery (Klima, Baxter and Patella, 1982). It is anticipated that correlative analyses of abundance patterns and environmental conditions will contribute to similar forecasts for other species in the future.

Salt Marsh Creation

Several NMFS projects address the value of transplanted salt marshes for fishery species (Minello, Zimmerman and Klima, 1987). One valuable demonstration is that increasing marsh-to-water edge in transplanted marshes can enhance marsh utilization by many fish species. Another project evaluates the functional development and equivalency of created salt marshes compared with natural salt marshes. At present, five natural and ten transplanted salt marshes are being compared for overall morphology, hydroperiod, slope, elevation, amount of marsh/water edge, percent of open water, sediment organic content, sediment grain size, growth of *Spartina alterniflora* (plant height, density, and above and below ground biomass), benthic and epiphytic algae (chlorophyll *a*, taxonomic composition) and densities of meiofauna, macro-infauna, and natant macrofauna. Caging techniques are being used to compare marshes on the basis of benthic infaunal productivity, predation pressure on infauna, and growth of penaeid shrimp. These experiments will determine whether differences exist in the ability of the marshes to support secondary productivity and whether habitat conservation and management should include marsh creation.

National Estuarine Inventory

Galveston Bay is also included as a component of the National Estuarine Inventory Living Marine Resources Project under development by NOAA's National Ocean Service. This program is designed to enhance our knowledge of species distributions and abundances by compiling previous research from literature and available data bases into a user-friendly database management system. Data on abundances of fishes and invertebrates, spatial and temporal distributions, and occurrences of different life stages are being compiled for the estuaries of the central and western Gulf of Mexico. Species profiles are underway that emphasize relationships to estuarine habitats.

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Status and Trends Analysis of Oyster Reef Habitat in Galveston Bay

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The purpose of this Galveston Bay National Estuary Program (GBNEP) study is to describe the status and trends of oyster (*Crassostrea virginica*) populations in Galveston Bay. The study consists of three primary tasks: the cumulation of historical data on oyster populations in Galveston Bay; the mapping of the extant oyster bottom in greater Galveston Bay including East and West Bays; and the assessment of the health of oyster populations.

All significant oyster reefs in Galveston Bay are being surveyed for their location, relief, and areal extent. The oyster reef survey requires the simultaneous collection of three types of data: (1) position and relief; (2) bottom type; and (3) verification of bottom type. Mapping of the extant oyster bottom will utilize continuous seismic survey techniques plus ground-truthing by tong or dredge coupled with state-of-the-art navigation. The seismic instrument combines a 22 kilohertz and 300 kilohertz transducer capable of distinguishing reef from soft-bottom while continuously underway. The navigational technique used is GPS (global positioning system).

Thirty to fifty sites are to be sampled in the Galveston Bay system for the health assessment. These sites will be sampled using a measured dredge haul obtained by GPS navigation, normalized by on-bottom time. A tripartite sampling approach will be used to assess the health of the oyster populations:

1. Community-based health assessments at each site will include:
   A. shell volume and number of boxes
   B. size-frequency
   C. predator abundance

2. Health assessments for 20 to 30 individual oysters will be obtained at each site and will include:
   A. condition index;
   B. condition rating (after Mackin);
   C. gonadal thickness and sex;
   D. *Perkinsus marinus* infection intensity

3. A more detailed health assessment will be made on some individuals at selected sites and will include:
   A. histopathological analysis;
   B. histological gonadal index

In the context of the GBNEP program, four to six sites in Galveston Bay have been sampled each year for the last five years under NOAA's Status and Trends Mussel Watch Program, along with sites in all other major bay systems of the Gulf of Mexico. *Perkinsus marinus* prevalence and infection intensity have been measured at each site. The data permit a comparison between the prevalence of *P. marinus* in Galveston Bay and in the remainder of the Gulf of Mexico.

Median infection intensity and prevalence were highest at sites on the north-central Texas coast, the Barataria Bay area of Louisiana, and southern Florida. Galveston Bay is one of three centers of infection of this disease in the Gulf of Mexico, the other two being Barataria Bay, Louisiana and Tampa Bay, Florida. The intensity of *P. marinus* infection did not vary with sex or stage of reproductive development. However, *P. marinus* was at its seasonal low for infection intensity and oysters were taken very early in the reproductive season. Comparison of the distribution of *P. marinus* among the Gulf bay systems indicates that centers of infection are associated with areas of high industrial land use and typically with oysters having higher than average body burdens of petroleum aromatic hydrocarbons and metals. Analysis of trends indicates that *P. marinus* responds to the El Nino/Southern Oscillation cycle in the eastern Gulf of Mexico and probably to a related climatic cycle in the western Gulf of Mexico.

In connection with the Texas Sea Grant program, a time-dependent model has been developed to assess the response of oyster populations to environmental variables and to determine the importance of population density in optimizing yield under varying climatic and hydrologic conditions. Initial simulations have been directed at Galveston Bay. Food supply in a typical Gulf of Mexico bay, Galveston Bay, would appear to be just adequate in most years to maintain a healthy, productive oyster population. Any decline in food supply, by reduced food content, lower current velocity, lower temperature, or increased population density, dramatically reduces oyster yield and can eliminate reproductive capacity. The effect of temperature on filtration rate exerts an overriding influence, establishing, much more so than respiration, the energy balance of the organism. one important aspect is the effect of latitude on population productivity and reproductive capacity. The effect of decreased food supply, for any reason, is felt more strongly at higher latitudes. In particular, higher winter temperatures can maintain higher productivity despite lower winter food supplies because filtration rates remain relatively high. Large adult oysters probably have a negative energy balance during the winter in colder climes, except under the most favorable of food supply conditions. By contrast, higher temperatures at lower latitudes reduces somatic growth and, consequently, yield because more of the yearly net productivity is expended in reproduction.

tus of Submerged Vegetation in the Galveston Bay System

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Submerged vascular plants (SV) provide valuable nursery habitat, organic production, and bottom stability in the estuarine environment. This aquatic vegetation is specially-adapted to estuarine factors which do not significantly impact emergent wetland species, and these physical and water quality growth requirements place strict limits on SV distribution and abundance. Despite documented cases of large-scale changes in SV habitat in other major estuaries, studies on Galveston Bay SV are limited. This report reviews the current status of SV communities throughout the bay and summarizes historical changes and impacts from environmental factors. It includes different SV types in three distinct regions of the bay system (Figure 1): (1) freshwater to oligohaline sites in the Trinity River Delta; (2) mesohaline environment of Trinity Bay proper; and (3) the polyhaline lower-bay environment of West and Christmas Bays.

Trinity River Delta

Two species of SV, *Ruppia maritima* (widgeongrass) and *Najas guadalupensis* (water nymph), were described by Benton *et al.* (1979) for some delta interior lakes. White *et al.* (1985) reported only *Ruppia* from the upper Trinity Bay area. The U.S. Fish and Wildlife Service National Wetland Inventory Program did not delineate SV distribution in their 1979 survey. Recently, the photography from the Benton *et al.* (1979) study was re-examined, and large beds of unidentified SV were observed near Southwest Pass and Jacks Pass (Pulich and Zimmerman, unpubl.; Figure 2). These beds were seen in the September 1978, but not the November sequences of photographs. White *et al.* (1985) actually mapped grass flat habitat at several of these locations based on 1979 photography. However, ground truth at these sites was not established in these earlier mapping studies. Despite lack of confirmation of species' identity, reports of occurrence of SV beds in this area dating back 25 to 30 years have also circulated among local fishermen and area residents.

Field surveys over the 1986 to 1990 period by Zimmerman, White, and Pulich have documented an abundance of *Vallisneria americana* (wild celery) and *Potamogeton pusillus* (pondweed) in many of these areas, in addition to *Ruppia* and *Najas* (Figure 2). *Vallisneria* was restricted exclusively to subtidal water depths (ca -0.2 to -0.8 m mean low water [MLW]), while the other species occurred in the shallower, intertidal zone. In the intertidal zone, *Eleocharis parvula* (dwarf spikerush) was also dominant at times. Seasonal biomass sampling

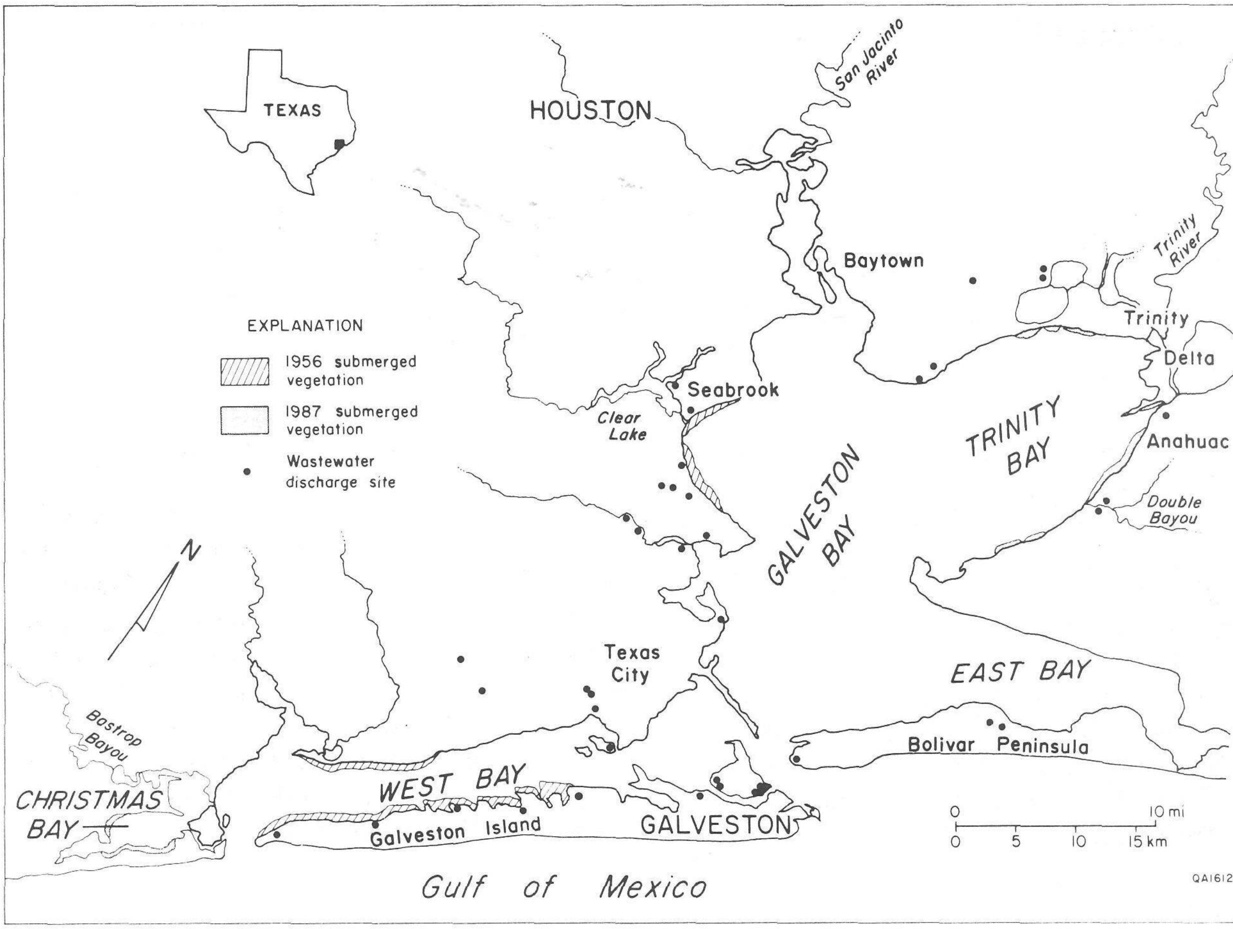

Figure 1. Map of Galveston Bay system comparing locations of submerged vegetation in 1956 and 1987. (Taken from Pulich and White, 1991, in press).

Vallisneria coverage is not available because of lack of adequate photography. Peak biomass values (gm dry weight per sq. meter) occurred at different times of the year: *Vallisneria* (47 -205 gm total in October); *Ruppia* (30 gm total in July); *Najas* (69 gm total in July); and *Potamogeton* (70 gm total in July). The response of species to salinity regimes during 1987 and 1988 was significant. Although salinities at study sites during 1987 ranged from 0 to 0.7 ppt and during 1988 ranged from two to 13 ppt, maximum *Vallisneria* production was high both years (200 gm per sq. meter in 1988). Substantial standing crops of all plant species were consumed by grazing waterfowl (ducks and coots), contributing to their rapid disappearance in mid-fall. Zimmerman *et al.* (1990) also showed preferential use of SV beds by fishery species compared to adjacent unvegetated substrate during late summer and fall periods.

These species are typical of a fluvial deltaic system characterized by high freshwater inflows and sediment deposition from the Trinity River. SV beds are mostly located in the more protected interdistributary areas of the delta. These areas reflect low rates of erosion (Paine and Morton, 1986) and low turbidity, conditions which are conducive to SV growth.

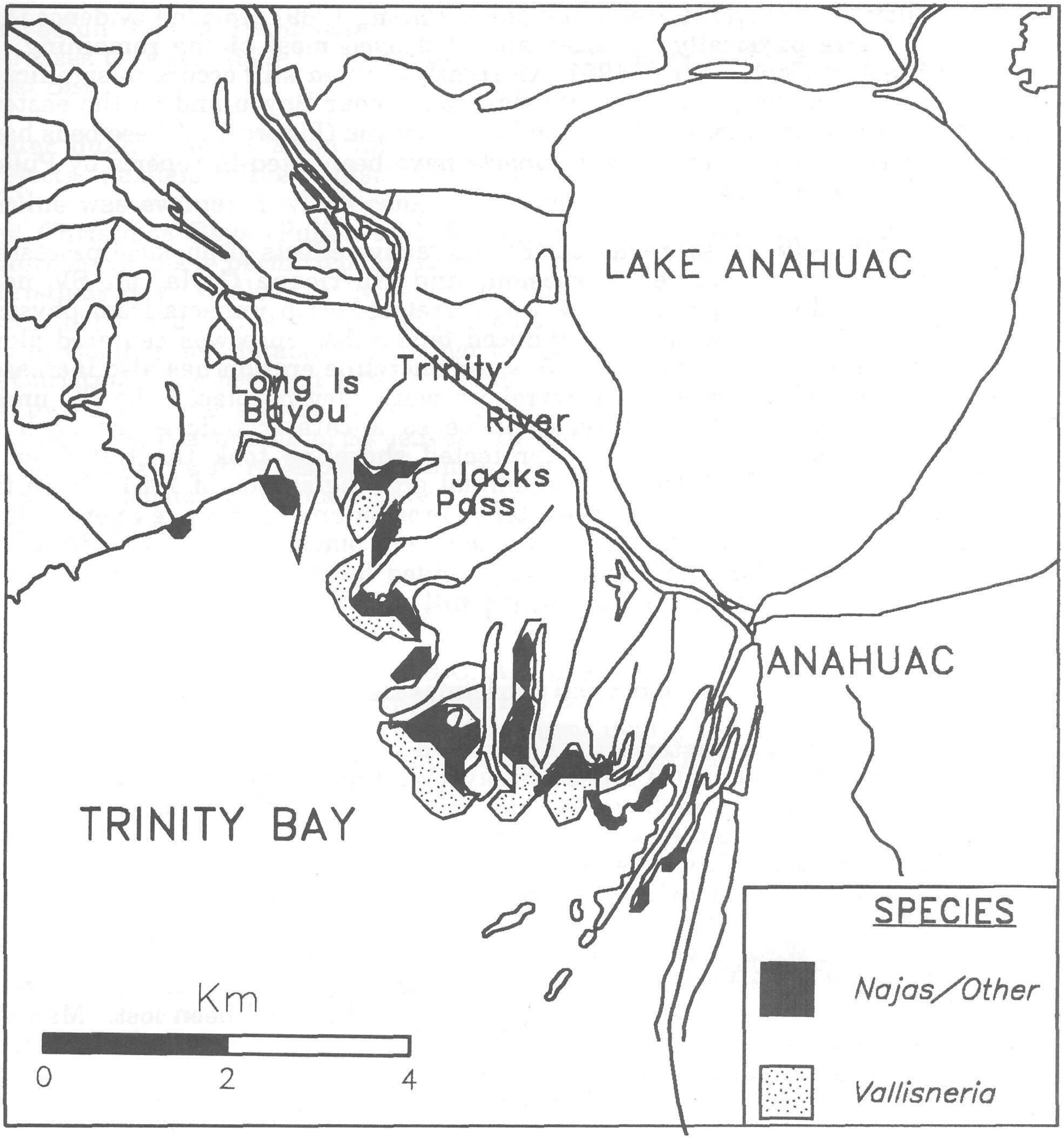

Figure 2. Map of Trinity River delta area showing main locations of submerged vegetation during 1987-1988.

Trinity and Upper Galveston Bay

Ruppia maritima historically occurred in upper Galveston Bay on the western shore from San Leon north to Seabrook and then to Pasadena (Figure 1). Today these grass beds are gone. Texas Parks and Wildlife Department (TPWD) personnel documented the decline and final disappearance of this SV in the early

1960s. Pullen (1961) and R. Hofstetter (pers. comm., 1989) provided evidence that Hurricane Carla physically uprooted and destroyed most of the remaining SV near Seabrook in September of 1961. Currently *Ruppia* still occurs in significant beds on the north shoreline of Trinity Bay near Cedar Bayou and on the eastern shoreline between the Trinity Delta and Double Bayou (Figure 1). These beds have been observed for many years, and impacts have been cited in reports by Pullen (1961) and Johnson (1974).

Pulich and White (in press) reviewed the interactive effects of physical processes, including subsidence, shoreline erosion, and Hurricane Carla, on SV near Seabrook. The disappearance of SV was correlated with impacts from physical and hydrographic factors. Human-induced land subsidence was centered along the Seabrook shoreline in the late 1950s and shoreline erosion has also increased there. The resulting increase in nearshore water depths placed the SV under considerable stress and left it susceptible to a catastrophic event such as Hurricane Carla. The exposed, unprotected shoreline took the full force of hurricane winds and fetch late in the annual growing season of 1961. With the destruction of SV in the fall and a winter of erosion and high wave energy along this shoreline, suitable SV habitat and a source of plant material was effectively removed. Evidence for this scenario is provided by the protected areas on the eastern shoreline across Trinity Bay which still support *Ruppia*.

West and Christmas Bays

True seagrasses have historically dominated in the polyhaline environment (salinity range 18 to 30 ppt) of the lower bay (West and Christmas Bays). Typical polyhaline salinities there have favored *Halodule wrightii* (shoalgrass) as a perennial dominant from the mid-1950s (West, 1973; White, *et al.* 1985). Until the mid-1970s, biologists from Texas A&M University regularly reported that *Thalassia testudinum* (turtlegrass) was also found in small patches in lower West Bay (*fide*, Kirk Strawn). In some years, significant amounts of *R. maritima* occurred around West Bay. Recent surveys by Zimmerman, Pulich, and White in 1987, 1988, and 1989 have revealed that major seagrass habitat exists only in Christmas Bay; all previously known beds in West Bay had been lost. Mapping studies showed ca 190 acres of SV in Christmas Bay, comprised of mostly *Halodule*; but substantial amounts of *Halophila engelmanni* (clovergrass) and a few small patches (ca 1/4 acre) of *Thalassia* were also located (Pulich and White, in press).

Pulich and White (in press) documented the chronology of seagrass decline for West Bay using definitive aerial photography from 1956, 1965, 1975, and 1987. Losses were correlated with critical physical and hydrographic factors including shoreline erosion, dredging and island development activities, and water quality degradation. Rates of shoreline erosion along Galveston Island increased during the period 1930 to 1982 more than any other place in Galveston Bay, and much of the change occurred between 1956 and 1982. Dredging of channels in nearshore areas probably enhanced erosion. In addition, spoil material from dredging was often disposed of in open water areas, burying adjacent seagrass beds and producing high levels of turbidity. The progression of dredged channels and

Galveston Island residential waterfront developments showed substantial increases between 1956-1965 and 1965-1975, coinciding with the decline of SV in West Bay.

Water quality degradation appears related to Galveston Island development projects, noxious effluent discharges and chemical spills. A scenario for SV decline was evaluated which compared water quality parameters between West and Christmas Bays (Pulich and White, in press). Five secondary treatment plants have been permitted on Galveston Island, while none discharges into Christmas Bay. While little evidence was found for increased levels of turbidity or total suspended solids in West Bay, some data were obtained from the Texas Water Commission database for higher chlorophyll *a* levels in West Bay compared to Christmas Bay between 1972 and 1980. Excessive nutrient loading can stress SV by stimulating growth of epiphytic and planktonic algae, which reduce the amount of light available to SV leaves. In addition, truly eutrophic conditions can produce anoxic waters, especially during warm, calm weather. Anoxia produced by such episodic events may have ultimately decimated many of the West Bay seagrass beds.

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